VOLUME 28, NUMBER 4

October 2012
through
December 2012

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The Journal of Technology, Management, and Applied Engineering© is an official publication of the Association of Technology, Managment, and Applied Engineering,

ATMAE
1390 Eisenhower Place
Ann Arbor, MI 48108

www.atmae.org

JTMAE The Journal of Technology, Management, and Applied Engineering

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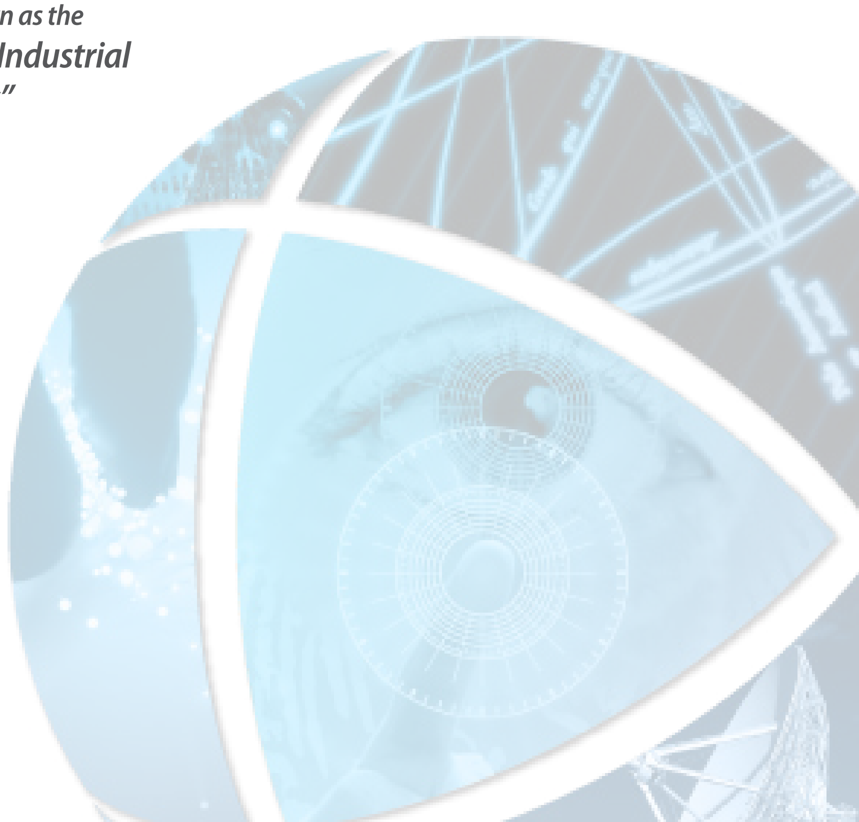
Keyword search:
Curriculum, Safety, Teamwork, Teaching Methods

PEER-REFEREED ARTICLE ■ APPLIED RESEARCH

formerly known as the
"Journal of Industrial Technology"



Student Laboratory Team Performance as Related to Team Size

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ABSTRACT

Several College of Technology faculty members undertook a longitudinal study to see if there was a correlation between student laboratory team sizes and students' achieving learning objectives. Commonly accepted logic would lead to a conclusion that as student laboratory teams become larger each team member has less direct interaction with the apparatus/equipment designed to convey/reinforce those learning objectives; therefore, and as consequence of this reduced interaction, students on larger teams would be less prone to mastering the learning objectives associated with the exercise. Conversely, smaller sized teams, due to higher levels of interaction with the apparati and lesser degrees of social loafing/disengagement would perform at higher levels than larger size teams.

Using the results of post-exercise tests, the performance of different sizes of student teams in a mechanical engineering technology laboratory was analyzed. The analysis failed to support a hypothesis that a correlation exists between team sizes of two, three or four students and individual student performance. However, these results may not be generalizable to all engineering technology laboratory environments.

THE LABORATORY EXPERIENCE

The fluid power technology (FPT) laboratory utilizes a team format consisting of students working in teams of between two-to-four individuals. Team members are self-selected and generally endure for an entire semester. FPT laboratory teams must complete an average of 20 exercises on six pieces of equipment. Exercises require student laboratory teams to configure equipment, perform specific operations relative to that configuration, collect data by observing and recording events, and perform calculations. Each experiment has an accompanying set of questions. These question sets require teams to: a) provide the answers to calculations, b) report observations, and/or c) respond to *what if* scenarios regarding changes in pressures, flows, or configurations. Assessment is based upon rubrics pertaining to the laboratory notebook. Are the calculations correct? Are the observations creditable? Do the responses to the *what if* scenarios reflect knowledge of the equipment and its underlying principles? Each team turns in only one notebook.

The fluid power technology laboratory team environment could be described as having both disjunctive and discretionary phases. Disjunctive tasks can be accomplished by an individual team member, with very little team learning taking place. Discretionary tasks allow individual team members to decide their level of contribution (Davies, 2009). The setup or configuration stages of the exercise would be the disjunctive phase; usually the team member with the most hands-on experience exerts a singular/authoritarian leadership. The discretionary phase occurs most often when the configuration does not function or only partially functions. Individual team members will lend their expertise or critical thinking skills to finding a solution.

LITERATURE REVIEW

Group work offers many benefits and challenges. The benefits include greater knowledge gains and an enhanced learning processes (Main, 2010). Group work is also associated with increases in students' collaborative, cooperative and communication skills (Davies, 2009). Groups can produce superior innovative products and have higher task completion rates (Main, 2010). Davies (2009) stated that group performance is the true measure of a student's employability. However, according to Main (2010), realizing these benefits generally requires that educators give adequate attention to the learning processes and not just to the knowledge content. This means that a minimalist guidance approach can jeopardize the group's effectiveness (Main, 2010).

Staats, Milkman, and Fox (2011) stated that team coordination and communication can suffer as team size becomes larger. Communication linkages and protocols become increasingly complex as team size increases (Staats, Milkman, & Fox, 2011). As teams become larger the potential for social loafing increases (Liden, Wayne, Jaworski, & Bennett, 2004). Social loafing refers to an individual team member's decreasing effort as the team sizes become larger (Kravitz & Martin, 1986; Piezon & Ferree, 2008). Liden, Wayne, Jaworski, and Bennett (2004) attribute the increases in social loafing to lower motivation, lower task interdependence and lower task visibility. Some team members have a strong need for recognition and if the potential for indivualism/recognition is low those team members can disengage (Piezon & Ferree, 2008). Piezon and Ferree (2008) attribute some of these behaviors to Equity Theory, which states that perceived inequities result in team member stress. Higher stress levels lead to social loafing. Davies (2009) differentiates between social loafing and free-riding. Social loafing is a reduction in effort due to an esteem or equity related issue. Whereas free-riding is an attempt to reap the benefits of the other team members' contribution while making only a nominal, if any, contribution to the team effort. Free riding creates a dynamic within the team known as the *sucker effect*. The *sucker effect* occurrs when team members perceive that they are being taken advantage of by the free rider. In an attempt to obtain or re-establish an equitable workload/contribution balance team members will reduce their output (Davies, 2009).

Contrasting to the social loafer and the free rider is the lone wolf (Barr, Dixon, & Gassenheimer, 2005; Hacker, 2000). Characterized by Hacker (2000) and Barr, Dixon and Gassenheimer (2005) the lone-wolf is a superior performer, an individualist, who prefers to work alone. Concerning team performance and task completion, the lone wolf will often shoulder the entire responsibility. Pieterse and Thompson (2010) describe the converse of the social loafer as a diligent isolate. The diligent isolate will take over a team, discourage inputs from others, and single handedly complete the project. This individual does not delegate or respect the technical/academic skills of team members; all that matters is completing the project.

Druskat and Kayes (2000) noted that, in the short-term, dysfunctional teams can receive high grades on projects with very little learning taking place. Group effectiveness can be compromised by the types of tasks they are assigned. Davies (2009) differentiated between task types and their suitability for group work. Disjunctive tasks can be accomplished by one group member and therefore foster non-participation. Conjunctive tasks require each member to participate in an assessed outcome; the outcome is a composite of everyone's contribution. However, since there are no discrete parts each contribution becomes detached from its contributor. Conversely, in additive tasks there are discrete components, which maintain linkage to the contributing team member (Davies, 2009). It follows that additive tasks may reduce social loafing and free-riding, but may reduce the interaction between team, and thereby reduce the potential for any synergism. Discretionary tasks allow students to determine their own contributions. These types of tasks require strong collaboration and communication within the group (Davies, 2009).

In addition to the type of task being assigned impacting group effectiveness, the method used in formation and the homogeneity of the group may be a determinate of group success (Pieterse & Thompson, 2010). Self-selecting groups will experience internal cohesion and good communication as a faster rate than assigned groups. However, self-selection can also lead to teams comprised of marginal performers who do not have the skill sets to function in a team environment or complete tasks. Pieterse and Thompson (2010) point out the necessity of having an academic balance within a group. Characterized by Pieterse and Thompson as academic alignment, academic balance refers to team members having similar academic abilities and skill sets. Conflict can result when an imbalance exists; team members become frustrated because of the comprehension and performance difficulties experienced by lesser accomplished team members.

RESEARCH TEAM SIZE AND TEAM PERFORMANCE

Research Question

Is there a correlation between student team sizes and team performance? In a limited resource environment, the number of laboratory sections being offered and the number of equipment suites necessary are constantly being challenged. Faculty and/or laboratory instructors are asked to extend class and laboratory sizes in an effort to create and leverage economies of scale, as well as accommodate students' scheduling desires/needs. Historically within the fluid power technology and power systems laboratories, student laboratory team sizes have ranged from two to four students, with three member teams being the most common. However, the number of three and four person teams has been increasing and on occasion circumstances have warranted a five person team.

Passed along as an inviolable axiom, laboratory team size protocols have been as much a part of the laboratories as was the equipment. The rationale was anecdotal; individuals on a two or three member team looked busier than the individuals of a four member team; therefore more learning must be taking place. However, there was no data to support the assumptions/perceptions that smaller teams were performing at higher levels. Nor did any data exist that supported the contention that having students in larger teams put those students at a disadvantage regarding achieving learning objectives?

In the current laboratory environment, assessment is done on a team basis. Each team turns in a notebook of completed exercises and all team members received a laboratory grade based upon the rubrics associated with the notebook. Prior to this research study, this inherited methodology made it difficult to assess the quality of individual student engagement and learning. Thus, this research agenda concerned determining if a correlation exists between the performance of individual team members and the number of team members.

Hypotheses

H_1: Pertaining to fluid power technology student laboratory team sizes of two, three, or four students, there is a statistically significant relationship between the students' performance and the number of team members.

H_0: There is no significant difference in the performance of students' that is directly or solely attributable to the number of team members.

Population Under Study

Students in the fluid power technology (FPT) course are the student population under study. FPT is offered every semester and the average class size ranges from 15 to 25 students. The FPT course is part of the mechanical engineering technology course offerings and is also a service course. Students majoring in Packaging Engineering Technology, Automotive Engineering Technology, and Electronics Engineering Technology take FPT as part of their curriculum requirements or as an elective. The course is structured on a 15 week basis with 10 weeks being lecture and five weeks of laboratory. Students are generally Caucasian males, ages ranging from 22 years to 45 years of age. Approximately 80 percent of the students are fulltime and majoring in an engineering technology. Among the remaining 20 percent of the population under study are industry professionals, veterans, and educators working on degree completion.

Experience within the Population

One major variable among students and student teams is the amount and quality of hands-on experience with mechanical systems. Pieterse and Thompson (2010) note that skill set imbalances are one of the challenges of allowing self-selected teaming. In this instance, some students have wealth of experience and other students have limited or no experience. One noted problem among has been the low credibility afforded to the communications of teammates with good critical thinking skills, but have limited or no hands-on experience. Their observations are often correct, but are readily dismissed by teammates.

Students enrolled in FPT are either juniors or seniors and have already had repeated exposures to working in teams prior to enrolling in this 300 level course. Most of these experiences have involved semester-length partnerships and projects. FPT student teams are together for at least eight weeks during the conduct of the course. Student teams become active during the pre-laboratory period of the course when student teams must complete several exercises and projects. Up until the laboratory portion of the course, students are free to dissolve and reform teams on a per-exercise basis. Once the laboratories begin the teams are permanent. Each team must submit a team members list, a team name, and name a team captain. The team captains functions as a communications conduit between the laboratory instructor and the other members of the team.

The broad spectrum of academic and work experience within the population under study must also be acknowledged. All majors within the college of technology are represented within the population. This relates to differences in preparatory coursework, which may impact team performance.

Research Design/Conduct

The research methodology was simply to keep the current laboratory protocols in place and then analyze team performance utilizing a between-groups ANOVA design with a pretest and posttest regimen. The expectation was that the resulting data distributions would be normal with similar variances. One-way and/or multiple factor ANOVA designs are often used to compare groups and analyze the effects of and interactions of various independent variables upon the dependent variable (Garson, 2012). The pretests and posttest would require that students must be able to: a) recognize various hydraulic and pneumatic instrument and device configurations; b) make statements about the operating characteristics of those configurations; c) outline the function and purpose of various components within a configuration; and d) match an application with a configuration. Garson (2012) noted that there are several methods of handling pretest and posttest data. One option would have been to conduct a one-way ANOVA on only the posttest data, which is according to Garson is a viable, but a not preferred option, since it ignores the pre-test data. Another option is to conduct a one-way ANOVA on the difference between the pre-test and posttest scores. This option was selected as the research design.

The population under study is an eclectic mix of backgrounds, ages, and other factors. It follows that a one-way ANOVA would not provide insight into the interaction of these factors or their effects upon the dependent variable. Thus the one-way ANOVA was acknowledged to be preliminary step and rejection of the null hypotheses would not be conclusive, but only inform the need for further study.

Design Modifications

Students, realizing how performance was calculated, began expending very little effort on the pretest, while making a concerted effort to score well on the posttests. This tactic resulted in inflated performance scores. As a result of the aforementioned limitations, the performance calculation was then modified to: a) exclude the pretest scores, b) focus on posttest scores as a measure of student performance, and c) associate that performance with a team size.

Another issue was the treatment of team data when team members were missing. This was especially problematic for three and four person teams. The resolution was that the team size data would reflect the configuration of the team during that exercise, irrespective of how many students were normally associated with that team. Thus, a four person team operating with two students absent would be entered into the dataset as a two person team.

Data Analysis

Tests were scored based upon the percentage of correct answers. The data was categorized according to team size and laboratory exercise, and then analyzed using SPSS 19. Table 1 provides the descriptive of the datase.

As a precursor to attempting the ANOVA analysis the distributions were checked for normality using histograms and Normal Q-Q plots. The visual analysis revealed that the many of the distributions departed the profile of what could be construed as normal. Subsequently, in an effort to quantify the amount of departure from normal, the Shapiro-Wilk test was performed using SPSS 19 with $\rho = .05$. As shown in Table 2, six out of the 15 datasets had distributions that could be characterized as nonparametric.

TABLE 1: DESCRIPTIVES

	Team Size	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min.	Max
						Lower Bound	Upper Bound		
Lab 1	2	4	.826	.181	.091	.538	1.114	.571	1.000
	3	46	.753	.213	.031	.690	.817	.143	1.000
	4	13	.846	.222	.061	.712	.980	.375	1.000
	Total	63	.777	.213	.027	.723	.831	.143	1.000
Lab 2	2	4	.786	.082	.041	.654	.917	.714	.857
	3	60	.600	.185	.024	.552	.647	.188	1.000
	4	12	.635	.251	.072	.476	.794	.250	1.000
	Total	72	.605	.196	.023	.559	.651	.188	1.000
Lab 3	2	4	.917	.167	.083	.651	1.182	.667	1.000
	3	30	.694	.243	.044	.603	.784	.166	1.000
	4	16	.815	.285	.071	.663	.967	.166	1.000
	Total	50	.750	.259	.037	.677	.824	.166	1.000
Lab 4	2	4	.694	.106	.053	.525	.864	.556	.778
	3	34	.738	.243	.042	.653	.823	.286	1.000
	4	8	.838	.085	.030	.767	.909	.714	1.000
	Total	46	.751	.217	.032	.687	.816	.286	1.000
Lab 5	2	4	.500	.297	.149	.027	.973	.143	.857
	3	12	.601	.293	.085	.415	.788	.143	1.000
	4	4	.594	.120	.060	.403	.784	.500	.750
	Total	20	.579	.260	.058	.458	.701	.143	1.000

TABLE 2: SHAPIRO-WILK TEST OF NORMALITY

	Team Size	Statistic	Degrees of Freedom	Significance
Lab 1	2	.899	4	.426
	3	.905	46	.001*
	4	.737	13	.001*
Lab 2	2	.729	4	.024*
	3	.931	27	.075
	4	.958	16	.629
Lab 3	2	.630	4	.001*
	3	.914	31	.017
	4	.688	16	.001*
Lab 4	2	.863	4	.272
	3	.887	34	.002*
	4	.893	8	.252
Lab 5	2	.998	4	.995
	3	.942	12	.521
	4	.863	4	.272

* P < .05

TABLE 3: KRUSKAL-WALLIS ANALYSIS

Exercise	Team Size	N	Mean Rank
Lab 1	2	4	35.38
	3	46	29.68
	4	13	39.15
	Total	63	
Lab 2	2	4	38.75
	3	27	19.31
	4	16	28.22
	Total	47	
Lab 3	2	4	17.38
	3	34	23.31
	4	8	27.38
	Total	46	
Lab 4		4	36.88
	3	31	21.71
	4	16	31.59
	Total	51	
Lab 5	2	4	8.75
	3	12	10.96
	4	4	10.88
	Total	20	

TABLE 4: TEST STATISTICS [a,b]

	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5
Chi-Square	2.941	9.491	1.524	7.284	.443
df	2	2	2	2	2
Asymp. Sig.	.230	.009*	.467	.026*	.801

a. Kruskal-Wallis Test
b. Grouping Variable: Team Size
*. P=<.05

A Kruskal-Wallis analysis was then conducted so determine if the differences in the teams' performance was significant at $\rho = .05$. As shown in Tables 3 and 4, the analyses determined that performance differences between student laboratory teams having either 2, 3 or 4 members was significant in only in the cases of laboratory exercises two and four.

Given the results of the Kruskal-Wallis test, a Mann-Whitney pairwise comparison analysis, with the Bonferroni approach to control Type 1 error, was undertaken to determine if a statistically significant performance change could be associated with the number of students on a team. The only instance of significance was in laboratory exercise two. Teams with two members (Mdn = .786) performed significantly higher than teams with three members (Mdn = .444), U=12, $\rho = .036$, r = .08.

CONCLUSIONS AND RECOMMENDATIONS

An analysis of student laboratory team data collected over a period of four semesters, involving 30 student laboratory teams, failed to find a statistically significant and consistent relationship between student laboratory performance and the number of students comprising a team. The interaction of variables outside the scope of this study may be the strongest determinants of team performance.

Discussion

This research, conducted in an environment with myriad variables, was intended to be a gross instrument to detect if there was a concern regarding laboratory team sizes and students achieving learning objectives. Had the data shown a correlation between laboratory team sizes and student performance, a follow-up with more sophisticated research effort would have been warranted. However, the resources needed to accomplish such a comprehensive research study are not readily available and generally will not be made available without adequate justification. It follows that this research study should be considered as preliminary to justifying the need for additional research.

There was a singular instance of teams with fewer members performing better than teams with a greater number of members. Specifically, in laboratory exercise two teams with two members performed significantly higher than teams with three members. This instance might have been noteworthy if for this same laboratory exercise this analysis would have revealed that teams with two members outperformed teams with four members and teams three members outperformed teams with four members. However, since the aforementioned did not occur, the null hypothesis, there is no significant difference in the performance of students' that is directly or solely attributable to the number of team members, cannot be rejected.

Given the resources available, this effort provided a level of solace that students in larger teams were not being placed at a severe disadvantage. While this limited research may have provided assurances that the fluid power laboratory learning objectives were not being compromised by having team sizes ranging from two to four students, it does not address all the factors that may impinge upon the student team size decisions. Preservation of the learning environment, particularly with regard to safety, should impact any decision regarding the number of students per laboratory team.

Concerning future research, it would seem prudent to engage in some form of low intensity, small resource consumption, longitudinal study that monitors the effects of laboratory changes on students. This is especially true in the case of inherited systems where protocols have existed ad infinitum without any assessment being undertaken. And while such assessments are commonly associated with learning objectives, in a laboratory environment safety assessments are equally relevant and should be given ample consideration when considering the number of students to admit and team sizes.

Limitations

There are numerous variables that can affect team performance. These variables, which include, but are not limited to, demographics, ethnicity, personalities, academic standing, and experiential factors, were not included within the scope of study. Attention must also be given to the methodology used to measure team performance. An end-of-exercise examination may not be a comprehensive measure of team performance. Team performance could have included measures of configuration set-up and problem resolution. Additionally, this study was insensitive to factors such as the sequence of exercise completion. There are limited sets of equipment and some trainers are more difficult to use than others. As a consequence, the sequence of exercise challenges varied from team to team. Others factors such as time of year/semester may also have affected results. Arguably, and as observed, team focus varies with the changes in the weather. As the weather becomes warmer teams are less inclined to spend protracted moments considering a problems.

Furthermore, the influence of the aforementioned variables on team performance may depend on the nature of the fluid power technology laboratory exercises. For example, in the fluid power technology laboratories, comparing actuator speeds, velocities are stated in terms of faster or slower. Would the results of this study have been the same if student teams were required to accomplish more sophisticated measurements? It follows that the results of this research may only be generalizable to laboratories using similar types and styles of laboratory equipment.

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